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Application of Dynamic Voltage Restorer for Sag and Swell in Voltage

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Abstract: *This paper figures out the problem of voltage sag and swell and overcome it. The most important aspect of electrical engineering is power quality in the current time. Power quality issues occur to the occurrence of substandard voltage, which may be current and frequency which may be damaged to power system equipment. One of the most important problems is voltage sag and swell. DVR is the device that can easily diminish those problems. DVR model compensates for the voltage sag and swells in an efficient and effective manner due to its lower cost, smaller size, and fast response of disturbance. This paper gives an introduction to the power quality problem and power electronics controllers for voltage sag and swells compensation. Then the operation of DVR is described.*

Keywords: *DVR (Dynamic Voltage Restorer), Microcontroller, Triac, Voltage Sag, and Swell, Power Quality*

I. INTRODUCTION

Power quality expresses the degree of similarity of practical power supply with ideal power supply. If power quality is good then any load connected to the electric network runs efficiently without decreasing its performance. If power quality is poor then any load connected to the network leads either to the failure of the equipment or reduction in its lifetime performance. In order to prevent the consequence of poor power quality and to improve the utility performance. The electric power is analyzed to resolve the power quality issues in order to determine the efficient compensation technique. The most serve problem that occurs in power system equipment is voltage sag and swell. Voltage sag is the decrease of normal voltage level between 10 to 90% of RMS voltage, for a duration of 0.5 cycles to 1 minute. Voltage swell is the increase of voltage beyond normal voltage level with a duration of more than three-cycle. This phenomenon is also known as the Ferranti effect. The most frequent way to improve power quality is to install DVR on the sensitive load side which provides both voltage compensation and fault current limiting function. DVR is a series-connected solid-state device that boosts voltage into the system by using injecting transformer to regulate the voltage at the sensitive load side. DVR can limit faulted current and protect the sensitive load. In this paper DVR essentially contain a microcontroller, TRIAC, rectifier, relay, transformer connected between supply and sensitive load. A microcontroller is the heart of DVR where its main function is to trace the presence of voltage sag and swell within the system, calculating the required compensating voltage for DVR and generating a reference voltage. The organization of the paper includes the introduction and principle of DVR. DVR compensation techniques, system configuration, control schemes, and lastly the conclusion of the work.

II. PRINCIPLE OF DVR

The basic principle of the DVR (Dynamic Voltage Restorer) is to inject a voltage of desired magnitude and frequency so that it can restore the load side voltage to the desired amplitude and waveform even when the source voltage is unbalanced. Usually, it employs SCR solid-state power electronics switches in a pulse with modulated inverter structure. To diminish the mitigation capability of DVR such as long duration voltage variation, the energy storage unit is necessary to supply the power transfer during the voltage compensation. The DVR can generate or absorb independently controllable real and reactive power at the load side. In other words, the DVR is a solid-state DC to AC switching power converter that inject voltage. The source of the injected voltage is the commutation process for reactive power demand and an energy source for the real power demand. The amplitude and phase angle of the injected voltages are different, thereby allowing control of the real and reactive power. Practically, DVR systems can to inject up to 50% of nominal voltage, but only for a short time (up to 0.1 seconds). However, most voltage sags are much less than 50%. DVRs can also reduce the damaging effects of voltage swells, voltage unbalance and other waveform distortions. The design according to the voltage needed in secondary of transformer.

III. OPERATING MODE OF DYNAMIC VOLTAGE RESTORER(DVR):

The basic function of the DVR is to inject a dynamically controlled voltage VDVR generated by a forced commutated converter in series to the bus voltage by means of booster transformer.

The momentary amplitudes of the injected voltage are controlled such as to eliminate the effect of a bus fault to the load voltage. This means that any differential voltages caused by transient disturbances will be compensated by an equivalent voltage generated by converter and injected on the medium voltage level through the booster transformer. The operating mode of DVR can be classified into three as below:

A. Protection Mode

In case of short circuit fault on load and high inrush current, the over current on load side exceeds an allowable limit. Then the DVR will get cut off from the systems by using the bypass switches and providing alternate path for current flow.

B. Standby Mode

Switching of semiconductors of VSI will not occur in this mode and the full load current will pass through the primary winding of injection transformer. The low voltage winding of the injection transformer is shorted through the converter in this mode.

C. Injection Mode

DVR injects voltage through the injection transformer to compensate for any disturbance detected in the supply voltage.

IV. CONTROL STRATEGIES IN DVR

There are several techniques to implement and control philosophy of the DVR for power quality improvement in the distribution system. Most of the reported DVR systems are equipped with a control system that is configure to mitigate voltage sags/swells. Other DVR applications that include power flow control, reactive power compensation, as well as limited responses to power quality problems.

The aim of the control scheme is to maintain constant voltage magnitude at the point where a sensitive load is connected. The control system only measures the r.m.s voltage at the load point, The control of DVR is very important and it involves detection of voltage sags and swells appropriately, which work in real time. Inverter is an important component of DVR. The performance of the DVR is directly affected too the control strategy of inverter. There have many studied been done by the researchers about the inverter control strategy for the DVR implementation. The inverter control strategy comprises of following two types of control as following:

A. Linear Control

Linear control is considered as a common method of DVR control. Among the linear control been used in DVR are:

- 1) Feed forward control
- 2) Feedback control
- 3) Composite control.

B. Non- Linear Control

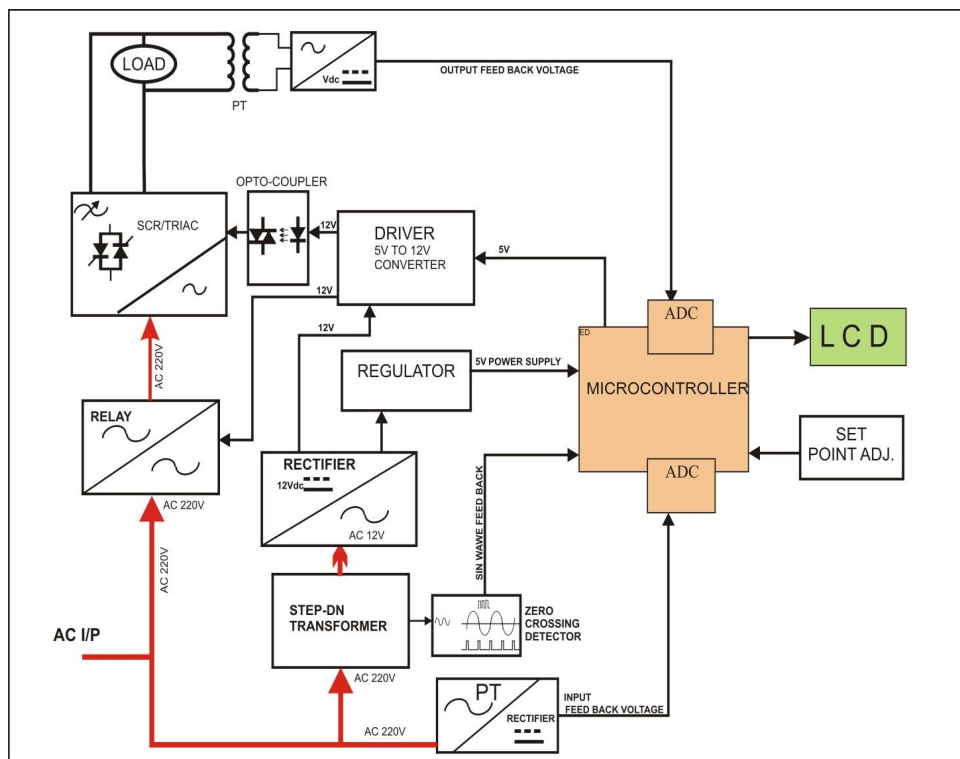
Due to the usage of power semiconductor switches in the VSI, then the DVR is categorized as non-linear device.

In case of when the system is unstable, the model developed does not explicitly control target so all the linear control methods cannot work properly due to their limitation.

Some nonlinear control methods are:

- 1) Artificial Neural Network (ANN) Control
- 2) Fuzzy Control
- 3) Space Vector PWM (SPWM) Control

V. BLOCK DIAGRAM



A. The Full Wave Rectifier (12VAC to 12VDC)

A Full Wave Rectifier is a circuit, which converts an ac voltage into a pulsating dc voltage using both half cycles of the applied ac voltage. It uses two diodes which one conducts during one-half cycle while the other conducts during the other half cycle of the applied.

B. Voltage Regulator (12VDC to 5VDC)

A voltage regulator is designed to automatically maintain a constant voltage level, where they stabilize the DC voltages used by the processor and other elements.

C. Sinewave Cycle Monitor (Zero Crossing Detector)

A zero-crossing detector is one type of voltage comparator, used to detect a sine waveform transition from positive and negative, that coincides when the i/p crosses the zero-voltage condition. In alternating current, the zero-crossing is the instantaneous point at which there is no voltage present. In a sine wave or other simple waveform, this normally occurs twice during each cycle.

D. Driver (5V to 12V Converter)

A Microcontroller digital logic output pin supplies only 10mA of current. External devices such as high-power relays can require >100mA and they need more voltages. In order to control such devices which, use high DC current, a transistor-based driver circuit is used to amplify current to the required levels. If the voltage and current levels are in perfect range, the transistor acts like a high-current switch controlled by the lower current digital logic signal.

E. Opto-coupler

An optocoupler is designed to provide complete electrical isolation between an input low voltage side (controller side) and output high voltage side (SCR/TRIAC side) circuits.

F. LCD

LCD (Liquid Crystal Display) screen is an electronic display module and finds a wide range of applications. A 16*2 means it can display 16 characters per line and there are 2 such lines. This LCD has two registers namely.

- 1) Command
- 2) data

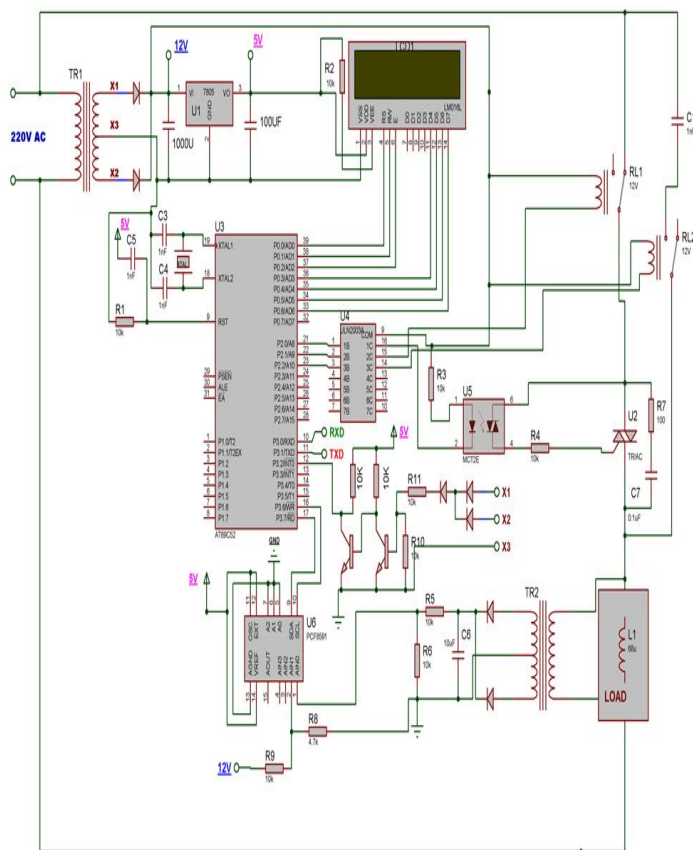
G. Thyristor/Triac

These are Static devices used to switch. The static device is a kind of device which converts one type of energy or energy level into another type of energy or energy level respectively without physical movement.

H. Micro - controller

The whole processing of the device is done by a micro-controller. The microcontroller 89s52 is a small but a powerful micro – controller from microchip. The AT89s52 is a low power, high performance CMOS 8-bit micro-controller with 8K bytes in system programmable flash memory.

VI. CIRCUIT DIAGRAM



In the above circuit diagram, the main aim is to regulate and keep balance the voltage across the load. Initially, the controller checks the incoming voltage coming from the line with the assistance of ADC (analog to digital converter) present inside the Microcontroller. Our aim is to control a positive (+ve), as well as negative (-ve) half cycle of incoming AC for that a Firing angle control method, is used. For controlling a firing angle of any AC voltage, it is necessary to monitor every positive-negative half-cycle, hence a Sine Wave Cycle Monitor (Zero Crossing Detector) is used, which informs a controller about the start point of every cycle.

Once the controller knows the voltage across the load and signals from the wave cycle monitor, the controller calculates the firing angle and provides a firing pulse to the AC-to-AC converter during which a static switch is formed by an SCR/TRIAC is employed. The static switch can be operated on a high voltage and high frequency as compared to mechanical switches like a relay. The output of AC-to-AC converter is further given to Reactor which is nothing but a type of single-core step-up transformer (220v to 320v transformer is used), which provides a 220v output at 140v AC input. The output of 220v is further employed by various loads. The voltage across the load is measured by the controller with the assistance of a Potential Transformer (PT). The potential transformer is used to step down the voltage across the load to be measured and rectified to DC because the microcontroller can read a voltage up to 5v dc only. we are employing a Relay for tripping the input which is beyond control-able limits. The relay used is 12volts and the controller can give a maximum of 5v, hence it's necessary to amplify the 5v to 12v that a Driver circuit is used. The microcontroller requires a 5v DC, and the same will be generated with the help of a Power Supply which comprises a Step-down transformer, rectifier, filter, and regulator. Transformer step down the 220v AC to 12vAC, rectifier, and filter converts this 12vAC to 12vDC and regulator converts a 12vDC to a constant of 5vDC. The capacitor bank is an optional that can be used in the case beyond limit regulation requires.

VII. CONCLUSION

This paper presents the problem of voltage sag and swell and compensate it by using **Dynamic Voltage Restorer (DVR)**. The introduction, principle, structure and operating mode of dynamic voltage restorer (DVR) have been elaborated in detailed. The main advantage of using DVR (Dynamic Voltage Restorer) is, its simple implementation, require less computational efforts, its control is simple as compared to other methods, smaller size, economical cost, quick dynamic response to the disturbance due to power quality issues and also less maintenance required. From this study of DVR applications, this work concluded DVR is suitable for compensation of voltage sag and swells. And also concluded the trend of DVR through the years are still assumed as a powerful area of research.

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